Study of Semi-conductors. (IV) : Electrical Resistivity of Spinel Type Semi-conductor

AUTHOR(S):

Abe, Kiyoshi; Tanaka, Tetsuro; Miura, Shigeru

Practically $BaTiO_3$ ceramic is cut in narrow strips, the sides of which are covered with silver frit. Two such pieces are fastened by soldering to the opposite side of a thin metal armature, which increases the mechanical strength of the strip, and also this symmetrical construction contribute to the flatness of frevuency response. The thickness of the strip must be determined from a compromise between a thin strip, which is preferable for the purpose of high capacitance, high compliance and small mass, and a thick strip, which is desirable for the purpose of the easy handling, freedom from the dielectric breakdown during the polarizing treatment. From the above point of view, we found that 0.25–0.3 mm was the best values.

Polarization takes about one hour in the field of 15000 V/cm, the exact time of which depends on the applied field.

The treated units are then assembled in a plastic cartridge. A sapphire needle with a tip of 0.06 mm radious is jointed to the armature arm. Rubber pads on either side of the assembly support it and at the same time act as lateral damper.

The characteristics of pickups produced on trial are as follows.

(1) output : 0.3–0.5 volt at 1k. c, on a standard test record.
(2) frequency characteristics : ± 10db (60 c/s–10000 c/s)
high resonant frequency : about 5000 c/s.
(3) internal capacitance : about 1000 pF at 20°C.
(4) tracking weight : 20 gram.
(5) needle point lateral compliance : 0.5×10^{-6}cm/dyne.

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5. Study of Semi-conductors. (IV)

Electrical Resistivity of Spinel Type Semi-conductor

Kiyoshi Abe, Tetsuro Tanaka and *Shigeru Miura*

(Abe Laboratory)

Recently, semi-conductors having spinel type structure are attracted much attention from electrical engineers for the reasons of their thermally sensitive resistivity, physically and chemically stable properties. Practically interesting spinel type semi-conductors are mainly consist of Fe, Ni, Co, Mn and some other metal oxide, the methods of preparation and properties of these materials are somewhat systematically studied.

In the prerarations of specimens, much attention were taken to avoid impurities, which probably give a remarkable influence on the conductivity. To get uniform specimens, all matarials were mixed at the state of nitrate. Oxide powders, obtained after heating, are pressed to a disc form (about 2 mm thick and 10 mm diameter) and fired in a furnace. Each specimen has a optimum firing temperature to become a perfectly sinterd ceramic, which usually lies between 1100°C and 1500°C.

Spinel type crystal is generally expressed by a formula of $AX \cdot B_2X$, or AB_2X_4, where A and B are divalent and trivalent metal respectively and X is divalent negative ion such as oxygen or sulpher.

Experiments on resistivity show that the next formula is valid in these cases.

$$\rho = Ae^{\frac{B}{T}}$$

But log ρ versus $1/T$ curves have mostly a kink at about 200°C. The values of B are 1000–8000°K, and generally large B corresponds to large ρ. For practical use, use, large B and small ρ is desirable. Co_4Mn_2, Mn_4Ni_2 and Mn_4Cu_2, Mn_4Ni_2 fulfil the above condition in some extent.

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6. Study of Semi-conductors. (V)

Dielectric Properties of Spinel Type Semi-conductor

Kiyoshi Abe, Tetsuro Tanaka and *Shigeru Miura*

(Abe Laboratory)

During the measurement about resistivity of spinel type semi-conductor, it was found that some of the specimens apparently had remarkably large dielectric constant at low frequencies. And accordingly experimental studies on dielectric properties of such materials were carried out. Measurements were carried about all specimens previously prepared for resistivity measurements, and anomalous large dielectric constant more than 10^4 was found among the specimens consisted of Fe–Co, Fe–Ni and Fe–Zn.

Specimens were again prepared for dielectric measurement, the method of which was similar to that of the preparation of specimen for the resistivity measurements. A parallel resistance bridge was employed for the dielectric measurements, and frequency and temperature characteristics of ε and tan δ were determined.

Generally high ε specimen has low resistivity, and high resistance specimen has low ε, but not all low resistance specimens have large ε. The dielectric constant generally becomes large according to the frequency decrease, and log ε nearly satisfies a linear relation with log f, at the frequency range of 10^2 and 10^4. If a linear relation exist

$$\varepsilon \cdot f^x = \text{constant}$$

where x is generally smaller than 1, but in some specimens such as Fe_9Zn_3, $Fe_{10}Zn_2$, Fe_6Co_6 and Fe_7Co_5, is nearly equal to 1.

The value of tan δ is commonly very large in these materials. The frequecy characteristics of tan δ have various curves of different kinds according to $\varepsilon \sim f$